MONTHLY WEATHER REVIEW.

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As far as practicable the time of the seventy-fifth meridian, which is exactly five hours behind Greenwich time, is used in the text of the MONTHLY WEATHER REVIEW.

Barometric pressures, both at land stations and on ocean vessels, whether station pressures or sea-level pressures, are reduced, or assumed to be reduced, to standard gravity, as well as corrected for all instrumental peculiarities, so that they express pressure in the standard international system of measures, namely, by the height of an equivalent column of mercury at 32° Fahrenheit, under the standard force, i. e., apparent gravity at sea level and latitude 45°.

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

SUGGESTIONS AS TO TEACHING THE SCIENCE OF THE WEATHER.

Outline of lecture by J. WARREN SMITH, at Teachers' Institutes in Ohio, August, 1906.

Practically all life and energy with which we are familiar comes from the sun. The sun undoubtedly controls all our weather conditions. There is no well established relation between the sun spots and the weather, notwithstanding recent newspaper writers to the contrary, but it is probable that there is a relation between the variations in the activity of the sun and the weather of our globe—not directly in well established lines, but indirectly thru a long chain of conditions that will produce different results in different places.

The moon causes a tide in large bodies of water, but its influence on our atmosphere produces a tide of only 0.004 inch on the mercurial barometric scale, and it has no recognizable influence upon the weather conditions.

The planets do not have the slightest influence on the weather, and people who pretend to predict the weather for weeks or months in advance by basing their calculations on the positions of the planets are deceiving themselves or are intentionally misleading the public.

The officials of the Weather Bureau believe that the time will come when we shall be able to predict the general character of the weather of a season, and possibly of a month, for several months in advance; but no reliable meteorologist believes for a moment that we shall be able to predict, several weeks or months in advance, the character of any day or the movement of any particular area of storm or fair weather across the country.

Very careful computations give the temperature of the surface of the sun at between 5000° and 10,000° F. This temperature denotes the energy of molecular motions that we call heat, and these motions, whether undulations or vibrations, move outward from the sun thru the ether of space with great rapidity and in every direction. The earth in its revolution about the sun intercepts less than one two-billionth of the energy of the solar radiation.

An iron ball attached to a chain so that it may be heated red hot and held up in the school room offers a most excellent example for illustrating and explaining solar radiation, as well as all the different radiation and absorption phenomena. A spectroscope or simple glass prism should be in constant use also. No scholar is too young to admire the rainbow and the other beautiful atmospheric colors, and to wonder how they are produced. Therefore no scholar is too young to have the colors of the spectrum shown him, and to have the principles of refraction, reflection, and diffraction illustrated and explained.

A scholar may not understand that the different wave lengths of solar energy make the colors of the spectrum possible, but it opens up wonderful fields of possible educational attainment to him when you explain that beyond the violet there are the unseen photographic or chemical rays, and beyond the red rays there are the unseen heat and electric waves. It may not mean much to some scholars to tell them that Schumann's shortest ultra-violet waves are something less than four millionths of an inch in length, or that Langley has measured the infra-red rays 529 millionths of an inch in length and Rubens and Nichols 944 millionths of an inch in length; but if you can get the scholar to inquire how these measurements are possible you have accomplished very much.

More recent investigations in connection with electric waves indicate that these may be several inches or several yards or even several hundreds of yards in length. They can be reflected, refracted, and polarized just as light waves; but altho these waves have many analogous properties, yet they have also fundamental differences.

Heat is transmitted by conduction, radiation, reflection, and convection. The principle of conduction is easily shown, as well as the difference between a good and a poor conductor. Radiation can quickly be explained by the example of the hot stove and the person of the scholar, or the red-hot ball and a thermometer. The fact that radiated heat does not necessarily heat the air thru which it is transmitted can be shown by holding one thermometer directly exposed to radiation from the hot ball and another thermometer behind a card even nearer the ball than the first thermometer. This experiment is desirable to enable the student to understand that the air is not warmed to any considerable extent by the direct heat of the sun.

Reflection of heat can be shown with the hot ball and a looking-glass; convection, by putting some sawdust into water and holding the dish over a burner, or by holding light tissue paper in the current of air rising from a hot stove.

With the hot ball and a square hole in a piece of cardboard, or by a simple geometrical drawing, you can quickly show that more heat can reach a given surface of the earth if that surface lies horizontal to the rays of the sun than if it is slanting. With the drawing you can show also that the sun's rays in passing thru the atmosphere have a less distance to go if they are vertical than if slanting.

Of the solar heat that strikes the atmosphere about 75 per cent gets down to the surface of the earth when the rays are vertical, 64 per cent with the rays at an angle of 50°, and 16 per cent with the rays at an angle of 10°. The rest is interrupted, chiefly by the moisture and dust in the atmosphere; so that while clean, pure, dry air is not sensibly warmed by direct solar radiation, yet the dust and moisture in the atmosphere does absorb some of that radiation.

The relative energy of the solar radiation that reaches the earth under vertical and slanting rays has been represented by one writer by the work of horses so standing that the shadow of any horse shall not fall beneath any other horse. Under vertical rays the horses can stand close together, while under very slanting rays they must be yards or rods apart.

Some dark bodies absorb radiant heat more rapidly than some light ones. To demonstrate this put a black leather and a light-colored leather cushion in the sun and place the hand on them after a little. Or coat the bulb of one thermometer with lampblack and paint the bulb of the other white and expose them to the radiant heat of the sun or of the red-hot ball.

All cooking utensils should be black and have a rough surface where exposed to the fire. I waited two solid hours for my dinner one day because an inexperienced cook tried to boil corn in a new tin pail. Light-colored clothing should be worn in the summer. The earliest ripened grapes are those hanging against a rough, dark wall.

When the heat rays strike the surface of the earth they raise the temperature of the surface of the land fully four times as fast as they raise the temperature of the surface of the water. Very little heat is reflected from the surface of the land, while a considerable percentage is reflected from the surface of the water. Heat is transmitted by conduction very slowly in the soil. The daily change in temperature is not felt deeper than about three feet in the land, but from 30 to 60 feet in the water. The annual changes in temperature are not appreciable below 65 feet in the land, but are felt from 300 to 600 feet deep in the water. At twenty feet below the surface of the land the maximum temperature occurs in December and the minimum near June. Part of the solar heat becomes latent in the act of evaporating a slight amount of moisture from the surface of the water, and part penetrates a considerable distance. And not only this, but when any part of a water surface is heated it may be replaced by convection by colder water. This can be splendidly shown by hanging the red-hot ball over one end of a tank of water in which litmus paper has been suspended.

Fresh water is densest at 39°. This explains why ice floats and why fresh water ponds do not freeze solid. By putting water at a temperature of 39° into a tall beaker, or tube, until it is nearly full and marking the surface line, one can easily show the expansion of water both as it is heated and as it is cooled. This is not true of salt water as that is densest at its freezing point, 29°.

The question will be asked how the air is warmed if not by direct insolation. The atmosphere absorbs a small proportion of the direct heat from the sun, and some of the radiated and reflected heat from the surface of the earth, but it is warmed to the greatest extent by conduction from the warmed surface of the earth and the objects upon it, and by convection between this warmed air and colder air. Therefore the air near the surface of the earth is warmest wherever the surface of the earth is warmest. This, in the summer time and in the daytime, will be over the land and wherever the solar rays are nearest vertical.

How is the air cooled? Heat radiates from all bodies constantly. When the receipt of heat is greater than the radiation the body is growing warmer. When the receipt of heat is less than the radiation the body is growing colder. Objects that are good absorbers are also good radiators; in general, dark bodies radiate heat more rapidly than light ones. Cut two cubes of ice of the same size and wrap one in a dark cloth and another in a light cloth of the same texture, and the one in the dark cloth will melt more quickly.

Take two tins, one bright and new and the other covered with lamp black. Put hot water in them and the water in the darkened tin will cool much more rapidly than the one in the bright tin.

Tea and coffee pots should be kept bright. The good steam engineer keeps his steam pipes bright and shining. The temperature of the air immediately over a dark colored lawn may be several degrees lower on a clear night than the air over a light colored lawn.

Ice is made during clear nights in dry weather in India and elsewhere by setting shallow, unglazed earthenware dishes on straw in the open air. The heat radiates very rapidly from the water, under the clear skies; the water is further cooled by the evaporation of water from the sides of the unglazed dishes; as they are set on straw heat can not be conducted to them from the ground beneath.

As the surface of the ground and the objects upon it are cooled by radiation at night, the air is cooled by convection and conduction of its heat to the cooled ground.

Moisture in the air, whether in visible or invisible form, absorbs radiation, and radiates in turn, so that heat radiated from the ground passes thru the air in clear nights, but is returned to the ground in damp, foggy, or cloudy nights.

Therefore the temperature of the air is lowest at night, and in winter time, over large land areas; and in clear still nights it is colder near the surface of the ground than at considerable distances above the ground. This is called inversion of temperature and this condition prevails on nearly every clear still night in winter or autumn, especially in valleys. It is under these conditions that by the drainage of cold air the temperature falls low enough in the valleys to cause a frost, while higher up on the hillsides there is no frost.

The air then is warmed by conduction from the warmed ground in the daytime, but at night it is cooled by the conduction of its heat to the ground that has been cooled by the radiation of its heat into space.

This leads up to the next important question, "What makes the wind blow?" The answer is, "difference in pressure". But what makes the difference in pressure? Two things—(1) difference in temperature together with the action of gravity, and (2) the rotation of the earth.

Let us consider that the air over a large land area and adjacent water area is in stable equilibrium and is still. The sun comes up, or the long days of summer come on, and the surface of the ground is heated faster than the surface of the water. The air in contact with the ground is heated by conduction, and it expands about 1/491 of its volume for each Fahrenheit degree of increase in temperature. In expanding it lifts the upper layers of the warm air over the land higher than the corresponding cool layers that are over the water.

Then under the action of gravity this higher air that has been lifted up over the land slides down onto the lower air that is over the water. This action decreases the pressure over the land and increases it over the water, and at once the surface air over the water is forced in toward the lighter air that is over the land, to equalize this difference in pressure, and so we have the surface action that we call "wind".

This is what causes the delightful sea breezes along the coast, the valley and mountain winds, and the monsoon winds that are best exemplified over India and the Indian Ocean. And this is what is taking place in a greater or lesser degree all over the globe wherever there is an unequal heating of the surface of the earth.

The pressure is greater and the barometer readings are higher in the winter time over the land of the temperate zone than over the water, and we have the drift of the air from the continents toward the oceans. In the summer time the reverse conditions prevail.

Looking at the globe as a whole, and considering the effect of the direct and the slanting rays of the sun, we may expect the air to be expanding and rising over the equatorial regions, overflowing above and moving out or sliding down toward the poles, then descending and flowing back toward the equator again. This is what is taking place, except that because of the rotation of the earth the centrifugal force is sufficient to force the air back, away from the centers of rotation, the poles, and pile it up at the Tropics.

Between the Tropics and the equator we have something of the ideal circulation. The air rises over the equatorial region, flows out overhead, down at the Tropics and back toward the equator as a surface wind. This surface wind is known as the "northeast trades" in the Northern Hemisphere, and the "southeast trades" in the Southern Hemisphere. But even here this ideal circulation is easily broken up and we often have strong surface currents flowing away from the equator.

Outside of the Tropics both the prevailing surface and elevated winds are from the west and there is no regular system of interchanging winds.

That there is no well developed upper current from the equatorial regions out over the temperature zones, was very well shown by the drifting dust and moisture from the explosion of the volcano Krakatoa, in the Straits of Sunda, in August, 1883. This dust drifted around the globe from east to west in fifteen days, but it took three or four months for it to drift from the Tropics northward over the temperate countries.

In all our discussion of the atmosphere, the movements of its currents and of the storm and fair weather areas, we must not lose sight of the extreme thinness of the shallow layer of air as compared with the horizontal distances that are under consideration. It is probable that there is a considerable atmosphere at 40 miles above the surface of the earth, but even at 10 miles above the earth the air is so thin and cold that it will not sustain human life.

At six miles above the earth in latitude 30°–50° the air is flowing steadily eastward at a velocity of 100 to 250 miles an hour, while practically all the atmospheric movements that cause our ordinary storms are within three miles of the surface of the earth.

Many of the storms shown on the daily weather maps control the weather from the Rocky Mountains to the Atlantic Ocean and from Canada to the Gulf. A storm influence covering a horizontal area fully 2000 miles in diameter may yet affect only an atmosphere less than three miles in thickness.

The next question that should receive our consideration in this chain of events that we are trying to link together, is the cause of rainfall.

The capacity of the air for moisture, or more properly speaking we should say the capacity of a vacuum for moisture, depends upon its temperature. At a temperature of 32° a cubic foot will hold 2.11 grains troy of water vapor. At 90° it will hold 14,790 grains troy, or over seven times as much as at 32°. If air at any temperature is completely saturated and is then cooled the moisture will be condensed and dew, fog, clouds, or rain will result. If air is three-fourths saturated its relative humidity is said to be 75 per cent. If air at a temperature of 80° and a relative humidity of 75 per cent is cooled down to 71.5°, its dew-point or point of saturation will be reached and condensation will take place, either as clouds or rain.

When the temperature of the vapor of the atmosphere is lowered to the point of saturation, condensation takes place about minute particles of dust and upon electric ions or electrons; or in the case of dew, upon the surface of the plants.

It is understood that nuclei of some kind are required for the formation of water drops, one nucleus for each drop. It has been found that when minute charges of electricity, carried on particles of matter which may be as small as one one-thousandth part of the mass of an atom of hydrogen, are introduced into a vessel of pure dry air and pure vapor of water, drops are able to condense.

Mr. John Aitken, who invented the dust counter, an apparatus for counting the dust particles in the atmosphere, believed that if there were no dust in the air there would be no fogs, no clouds, no mist, and probably no rain; that dustless air, when it became supersaturated would condense on all objects on the surface of the earth. Every blade of grass and every limb of a tree would drip with moisture deposited by the passing air. Our clothes would become wet and dripping, and umbrellas would be useless.

Such a condition is sometimes found to prevail on the summits of high mountains when the dust counter shows an extremely small amount of dust in the air. Some of the observations with Aitken's dust counter showed that in apparently clear air there were over two million dust particles in a cubic inch. In an ordinary room there were over thirty million, and in a Bunsen flame nearly five hundred million. "What must be the size of these!" says one writer. "Millions in a cubic inch, and yet so light that their united mass can not be weighed, and most of them invisible with the highest power microscope".

When air is compress its temperature rises, and when it is expanded the temperature is lowered. When a body of air is raised 300 feet its temperature is lowered 1.6° because of the expansion of the air due to the lesser weight of the air above it. When a body of air is lowered 300 feet it is warmed by the same amount.

Therefore, when a moving current of air with a temperature of 80° and a dew-point of 70° is raised about one-third of a mile (2000 feet), clouds and possibly rain are produced. Air that is nearly saturated has to be raised very little to produce rain.

The conditions which produce the cooling of the air that is necessary for the formation of clouds and rain are:

1. The elevation of moist air and the consequent cooling by expansion.
2. Poleward moving masses of air, or a current of moist air from over the ocean moving on to the colder land.
3. Mixing of two masses of air of different temperatures.

Thus, wherever we have a body of moist air ascending rapidly, whether because of the release of pressure by the removal of air aloft or whether moving up the side of a mountain, or wherever we have a body of moist air moving onto colder land or moving far northward into a region of lower temperature, we have clouds and rain.

On the other hand, wherever we have a volume of descending air, either air settling down over a large area, or wind blowing down the leeward side of a mountain range, the air is being warmed by compression, its capacity for moisture is increasing and clear skies prevail.

The northeast monsoon winds over India give no rain because they are descending, warming and drying winds, while the southwest monsoon winds, because they are very warm and nearly saturated, give the heaviest rainfalls of the globe wherever they flow rapidly up the steep mountain side.

The extreme northwest coast of the State of Washington has an average rainfall of over 100 inches a year, while just east of the mountain range in the central part of the State the fall is less than fifteen inches.

I have been telling you some facts that you may already be familiar with, but my purpose has been to help you grasp the correlation of these phenomena in a large way. The whole chain of events can be very briefly exprest.

The source of all our weather changes is the sun. Its radiant energy warms the surface of the globe unequally. The air is warmed by conduction from or cooled by conduction to the warmer or cooler ground, respectively. Vertical and horizontal currents are set up in the air because of its expansion by warming or contraction by cooling, and are modified by the rotation of the earth. Ascending currents of air are rainy, descending currents are dry. The temperature of any place depends upon the latitude, elevation, slope or aspect of the surface, proximity to land and water, and prevailing winds. The rainfall is influenced by topography, prevailing winds, and the character of the country over which the winds blow.

The present movement to increase interest in nature study in our schools is an excellent one. The most successful men have been those who are most practical, men who can understand and make the most out of their environments.

The country boy is often more successful than the city bred boy partially because he has developed habits of personal observation and experience—because he has had natural and not artificial things around him. He sees nature in a large way and is quick to grasp conditions and foresee results.

Therefore the educational movement to teach all children something of the principles of growth and the conditions that promote or retard growth in both the animal and vegetable kingdoms is an excellent one.

We frequently hear of the college professor who pulled up his beans and planted them over again because they were coming wrong end up. Only a few days ago I read of the finding of a gate high up in a tree not far from Johnstown, Pa. The explanation given in the paper was that the gate had been carried down the stream during the damaging floods of a number of years ago, had lodged in the limbs of a small tree, and had been carried to its present great height as the tree had grown up. When your present nature-study plans have been fully developed no boy will grow up in such ignorance of the principles of plant growth as was indicated by this article. In all of your teaching in this direction the weather enters into your scheme more than any other factor, and it is one of the easiest to get valuable illustrations from.

The relation between the weather and the growth and yield of crops is very important from a practical point of view. For example, Professor Gibbs, of New Hampshire, and myself have determined that the yield of corn in the United States depends largely upon the July rainfall. From investigations in Ohio I have demonstrated that the poorest yields of oats are with warm, wet summers, and the best yields with cool, dry summers. Barley, on the other hand, does best in warm and dry weather and poorest in cool and wet summers. In South Australia, where they have 8 to 10 inches of rainfall a year, they can keep only 8 or 9 sheep for each square mile. In New South Wales, where the rainfall is 13 inches, they can keep 96 sheep on a square mile, and where it is 20 inches, 640 sheep. In Buenos Ayres, where the annual rainfall amounts to 34 inches, they can keep 2630 sheep on each square mile.

In Jamaica, when the rainfall for any year averages 56 inches, the average sugar export during the following season is 1441 casks per acre; when the rainfall is 76 inches, the export is 1559 casks, or about one-tenth more. This means an increase in the value of the sugar crop of about $400,000.

In Canada the school children have been encouraged to notice and report the blossoming of plants, leafing of trees, the coming of birds and insects, and the progress of farm work, to a far greater extent than has been done in the United States. They have a list of over one hundred things that can be reported on, and the school that makes the greatest number of reports and the individual scholar that makes the greatest number of reports is awarded a prize.

Observations of this character should be encouraged, and if any teacher wishes to take up such observations I shall be glad to assist in arranging the plan and the subjects to be considered.

All teachers in this State should take advantage of the agricultural extension work offered by the Ohio State University under the direction of Prof. A. B. Graham. The Agricultural Extension Bulletin that he publishes is of remarkable helpfulness in suggesting and directing plans and methods. Phenology, as it is called, relates to the study of the relation between weather and vegetation or animals, and one of the most fascinating branches of the study is that which relates to the effect of the weather on man.

Every teacher has experienced "cross-grained" or unruly days, when everything goes wrong, and it is probable that you have ascribed the trouble in some indefinite way as being due to the weather. But has it ever occurred to you that you might take some observations along this line that might be of direct value to science and to humanity?

During London fogs, and on days when the weather is particularly depressing, it is said that in the Bank of England, certain sets of books, an error in which would be accumulative and produce disastrous results farther on, are locked up, and the clerks set at tasks less intricate and important in character.

The same necessity for a cessation of certain lines of work during bad spells of weather is recognized by the large banking institutions in New York and other cities.

The head of a factory employing 3000 workman has said: "We reckon that a disagreeable day yields about 10 per cent less work than a delightful day, and we thus have to count this factor in our profit and loss account". But what is an "unfavorable" day and what is a "delightful" day? Prof. Cleveland Abbe, of Washington, and Mr. W. F. Tyler, of Shanghai, have suggested that we make out personal weather curves, of comfort or discomfort, by recording the different weather elements on days when we feel perfectly comfortable or exceedingly uncomfortable, unusually deprest or unduly elated.

Prof. Edwin Grant Dexter has investigated this subject quite carefully and has evolved many very interesting conclusions.

A RARE CUMULUS CLOUD OF LENTICULAR FORM.

By HENRY HELM CLAYTON. Dated Blue Hill Observatory, Hyde Park, Mass., May 8, 1906.

The accompanying figures 1, 2, and 3[1] present a rare cloud form photographed by Mr. Frederick Endicott, of Canton, Mass.,[2] about 1 p. m., on April 22, 1898. The form is one which has been named "lenticular cumulus" by Clement

[1] The same chimney pots appear in each of the photographs; in fig. 1 they are at the right edge, in fig. 2 somewhat to the left of the middle line, and in fig. 3 they are at the left edge. In fig. 1 a windmill shows the direction of the wind. The clouds moved in the same general direction. The cloud at the right in fig. 1 is the same as that on the left in fig. 2, and the cloud at the right in fig. 2 is the same as that at the right in fig. 3. The times of exposure were evidently in the order of the figures, 1, 2, and 3, since in each case the clouds drifted in the direction from the chimney pots indicated by the windmill.

The arrangement of the bases of the clouds in parallel bands shown on the right and on the left of figs. 1 and 2 indicates the presence of large atmospheric waves, of which these clouds probably formed the crest. This arrangement of the clouds in parallel bands is not uncommon in the case of ordinary cumulus. It is possible that the striations in the cloud were in some way related to the atmospheric waves.

[2] About three miles south-southwest of Blue Hill, Mass.